

Clear-Sky Longwave Downward Flux Validation: Model A (Inamdar & Ramanathan)

The downward clear-sky longwave flux, estimated through this method, depends closely on the atmospheric greenhouse effect, defined as the difference between the surface and the top-of-atmosphere LW emissions, precipitable water and the near surface air temperature. The LW flux is derived separately for the window (8 - 12 micron) and non-window spectral regions and then the two components are summed to obtain the broadband flux. Details of the physical basis of the parameterization are available in Inamdar & Ramanathan (1997) and also through the [ATBD document "Estimate of Longwave Surface Radiation Budget From CERES"](#) (PDF).

Parameterizations have been developed separately for the tropics (30 N - 30 S) and extra-tropical (30 degree to pole) ocean regions and only tropics (30 N - 30 S) for the land surfaces using a database of tens of thousands of sondes. The theoretical estimates of standard error between the fluxes estimated from model runs (using sondes as input) and those predicted from the parameterization are as follows:

Open Ocean (Tropics)	4.4 W m ⁻²
Open Ocean (Extra-tropics)	3.2 W m ⁻²
Land (Tropics)	6.2 W m ⁻²

Limited validation studies employing data from Central Equatorial Experiment (CEPEX), reported in the study cited above, reveal good agreement consistent with the above error estimates.

The basic structure of the operational algorithm for the tropical land case is similar to the one described in the Tellus paper (see Table 3 in Inamdar & Ramanathan, 1997). However, for land, the regression coefficients are slightly different for the following reason. The operational version of the algorithm employs two different emissivities for non-black surfaces, namely one for the window (8 - 12 micron) and another for the broadband region (referred to as WIN and LW emissivities in the SSF data set), unlike in the published paper wherein only one emissivity (8-10 micron) has been used. Thus the parameterization developed for the tropical land surface for operational use have been modified accordingly. The equations are given below:

Tropics (Land): 30 N - 30 S

$$(1) f_{0,WIN}^- = 3.24046 g_{a,WIN} + [0.1357 w_{ZTC} + 2.79501 \tau + 0.04312 (T_s / 300) + 0.12529 (T_a / 300)] f_{\infty,WIN}^+ - 0.01174$$

$$(2) f_{0,LW}^- = 0.2883 g_{a,LW} + [0.06173 \ln(w_{ZTC}) - 2.10669 (T_s / 300) + 2.55014 (T_a / 300)] f_{\infty,LW}^+ + 0.42497$$

The near-surface air temperature (T_a) is represented by the air temperature defined at a pressure altitude of 950 mb. Fluxes have not been calculated for regions with surface pressure less than 950 mb. The broadband flux can be obtained by summing (1) & (2). Thus,

$$F_0^- = (f_{0,WIN}^- + f_{0,LW}^-) \sigma T_s^4$$

Please note that the equations for the ocean case are identical to those in Table 2 (Inamdar & Ramanathan, 1997). It is also worth noting here that the fluxes have not been estimated over the extra-tropical land surfaces, sea ice-covered surfaces and glacier regions.

Other possible sources of errors in the archived fluxes are:

1. Specification of the true radiating temperature of the surface and the near-surface air temperature (especially over land surfaces);
2. Errors in scene identification (especially snow and ice-covered surfaces are prone to such errors);
3. Emissions from aerosols in the boundary layer. For example, sensitivity studies have shown that thick haze in the boundary layer (visibilities less than 15 km) can increase the downward emissions by about 3 - 5 W m⁻²